# The Air Line Pilot

October, 1954

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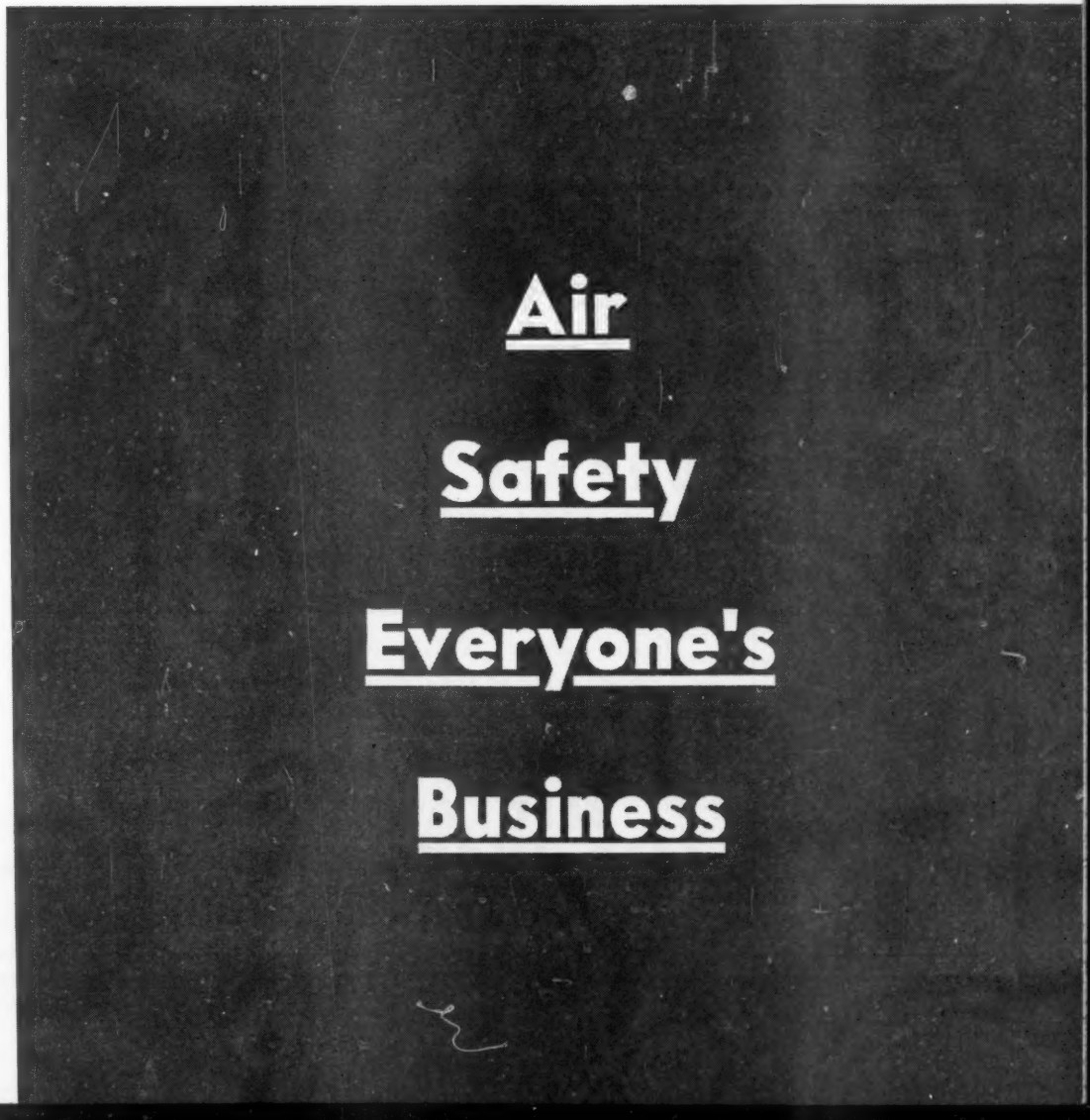


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# The Challenge Of Air Safety . . .

**Anyone who flies planes, operates planes, makes planes, rides in planes, or is interested in country's welfare has a stake in air safety.**

By J. Carlton Ward Jr.

*Chairman, Board of Governors, Flight Safety Foundation*

The title of this article—"The Challeng of Air Safety"—has a number of hidden meanings which are not apparent on the surface. Before going into the challenge itself, it would be well to ask a few questions:

### Some Questions

▶ To whom is the challenge directed? Is it to the pilot—the management of airlines—the manufacturers of airplanes—to the passenger—or to the Government?

▶ Why is there such a challenge? Air safety would seem to be as vital to aviation as breathing is to staying alive. Are we challenging the need of air safety, or the way the need is being met by the people responsible for air safety? Or are we challenging the methods by which air accidents are being combatted?

▶ Is the challenge on technical grounds, or is it directed toward human factors involved in air safety? Is it a challenge of procedures, or of attitudes?

### The Answer

It is possible to answer all these questions with a single, all-inclusive answer: Air safety is everybody's business, and everything mentioned above is included in the problem. If you fly airplanes, operate airplanes, make airplanes, ride in airplanes—or if you are simply interested in the welfare of our country—you have a stake in air safety.

There will never be too much safety in the air. If there were sufficient air safety—or if we were doing everything we can do—there would be no challenge. We wouldn't be talking about it.

Aviation has come of age, and we can afford to face facts. In order to do this, we must review the facts. We must know exactly what our aims are in developing those things which promote safety, and combatting things that retard safety.

### The Old Attitude

Let's go back a bit. Years ago when the flying business was more or less in its infancy, there was a hush-hush attitude toward air safety. People who flew airplanes or operated them did not like to have people talk about safety. It scared them away from the planes.

When a plane crashed, the idea was

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to cover everything up—smear paint on the insignia, so nobody would know what airplane had the accident; say nothing about the reasons for the accident, on the ground that talking about it would increase fear.

We all know today that this was poor public relations. It was not even good common sense. We have outgrown a good deal of this early attitude of sticking our heads in the sand—but not entirely.

Air safety has gone through an evolution that is very much like the public attitude toward certain diseases—such as cancer and syphillis. Years ago newspapers would not print the cause of death of people who died from cancer. They were afraid it would arouse fear in the public mind.

### The New Attitude

Today that has changed, because the public and the medical profession both know the best way to stop cancer is to know about it—to spread information as to its causes, and what can be done to arrest its progress, so that those afflicted may take the earliest possible steps to arrest the disease.

There is a lesson for the aviation industry in the history of the public attitude toward cancer.

Mystery breeds anxiety and suspicion and retards progress.

We are willing to discuss safety now because certain phases of flying have become safer than other common activities like riding in a car. Airline flying is of the same order of magnitude as the safety of railroads and a great deal safer than driving a car. U. S. international operations are about 40 times safer than car-driving, based on current fatality statistics.

### The Greatest Challenge

Our greatest challenge is to obtain a perfect safety record. Perhaps we will attain that point of perfection where there are no accidents. But if we keep our sights high enough, we will keep on improving even if we never reach perfection.

Let us consider, for example, the human factor in flight safety—the challenge to the people who manufacture, operate, maintain and fly airplanes, as well as those who ride in them.

Starting with the last, let me quote from General Harold Harris:

"Anxiety is still a predominant part of the human equation of air transportation. It will continue to be as long as an accident can happen. Anxiety is inherent in the human reaction to air transportation whether the reaction be conscious or unconscious. Anxiety never disappears in a human being in an airplane—it merely remains dormant when there is no cause to arouse it. Our challenge is to keep it forever dormant."

At first the challenge was directed primarily for the passenger. But since the unfortunate accidents at Newark airport, the anxiety has extended to those who live around airports.

### Anxiety and Safety

One of the popular ways of combatting this anxiety has been to quote figures as I just did, showing how many times safer an airplane is than an automobile, or comparing passenger miles flown without accident to records of other forms of transportation. This in itself is a plain admission that we know this anxiety exists, and we are trying to reduce it or allay it.

But reducing anxiety does not increase safety, any more than keeping the word "cancer" out of the newspapers cured the disease.

We are all sure that flying will become one of the safest forms of transportation, but we won't make it safer by putting our heads in the sand—either individually within segments of the industry, or collectively as an industry.

The question boils down to this: Not, "How can we convince people that flight safety is improved?" But, "How can we improve flight safety?"

### Good Business

Obviously, it is good business to be on friendly terms with the people who ride in airplanes, and who support air transportation. We know that even as our safety rate improves, the increasing activity and frequency of flights will cause a greater number of accidents—and steps must be taken to keep this in proper public perspective. Automobiles can go on killing people at an ever-increasing death-rate without creating as much sense of calamity in the public mind as two or three major airplane accidents in close succession.

But our interest goes deeper than this. The cost of accidents to airline management, and to manufacturers who have an indirect but no less vital interest, are such that management can no longer sustain the position: "Can we afford to do this for increased safety?" Rather, they must ask: "Can we afford not to do it?"

### No Panacea

There is no panacea for airplane accidents—no sure way of preventing them.

What I want to discuss is the variety of human relationships which the Flight Safety Foundation has found in its investigations that materially effect the prevention of accidents.

If maximum flight safety is to be attained, these human problems must be recognized, evaluated, and dealt with constructively.

First and foremost, there is a man's attitude toward his job. For example,

*(Continued on Page 14)*

Vol. 23, No. 10

**The Air Line Pilot**

**October, 1954**

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Published Monthly by the Air Line Pilots Association, International, Affiliated with A. F. of L. Publication offices: 55th Street and Cicero Avenue, Chicago 38, Illinois.

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Annual Subscription, $2.50

Ed Modes, Editor

# Airborne Radar--A Forward Step

**UAL has announced it will equip 150 planes with airborne radar next spring. Significantly, too, it will be designed specifically for air line use, not a military modification.**

By Ed Modes

*Editor, The Air Line Pilot*

United Air Lines has broken the ice on airborne radar—to pilots, one of the most welcome cockpit additions in many a year; to the industry, a step that should pay rich dividends in increased safety and reliability. Dollarwise, United will put $4,000,000 into the radar program. One hundred fifty of UAL's four-engined and twin-engined planes will be radar-equipped.

By its action, UAL becomes the first air line to adopt airborne radar specifically designed for commercial use, according to J. R. Cunningham, the company's director of communication. He points out that the equipment would not be a modification of any military type radar but, rather, will be the product of research and development directed entirely toward radar use in air line operations.

### A Forward Step

There is no dispute that airborne radar looms as a significant forward step in the application of latest scientific devices in air line operation.

W. A. Patterson, President of UAL, says: "I regard radar for air line use as one of the great technological advances of the last 10 years."

Speaking for the Air Line Pilots Association, C. N. Sayen, ALPA president, expressed warm praise for the program being instituted by United.

"We are confident," he said, "this decision to purchase airborne radar will reflect in increased schedule reliability, safety, and passenger comfort, and will ultimately benefit the entire air transport industry. The inclusion of airborne radar in the cockpit will help the pilot, by visual reference to a radar scope, to determine the location of thunderstorm cells, heavy precipitation, turbulence and icing areas and will help to insure proper terrain clearance. Tomorrow's pilot, with the aid of this navigation device, will be better able to analyze the weather, plan his flight accordingly while en route, and thus avoid many of the potential hazards associated with flying in thunderstorm areas."

### International in Scope

United, Sayen said, is taking the lead in meeting an air transport problem that is not only national, but also international in scope.

Speaking as president of the world pilot organization, the International Federation of Air Line Pilots Associations, Sayen recalled that the International Federation, at its 9th Conference in Zurich, Switzerland, in April, 1954, reviewed the problem and adopted a resolution pressing for the inclusion of airborne radar in all transport aircraft. The IFALPA resolution states: "The Federation, collectively and through member organizations, insists strongly that airborne radar adapted to the specific purpose of providing the pilot with information to aid in (1) turbulence circumnavigation, (2) evasion of icing areas, and (3) terrain clearance, be installed in commercial aircraft as soon as possible."

"Airborne radar," said Mr. Sayen, "is one of the greatest technological advances in recent years in the air transport field. We hope that other carriers will shortly follow United Air Lines and make airborne radar available to their pilots."

### Weather Mapping Use

Specifically, United will use C-band radar for weather mapping. This means that pilots using the radar will be able to peer into storm fronts and select corridors through which they can fly dependably and with the assurance of maximum passenger comfort. The result will be the avoidance of turbulent areas and the elimination of lengthy detours around storms.

Using an experimental C-band radar developed by the Radio Corporation of America, United last summer conducted four months of flight tests which, air line officials said, clearly demonstrated the superiority of the C-band frequency for weather mapping (reported at the 1954 ALPA Air Safety Forum and in June, 1954, Air Line Pilot). Altogether, 40 technical and operational flights totalling 133 air hours were completed in the area around Denver where a series of thunderstorms provided ample opportunity to gauge the potentials of airborne radar.

### "Sir Echo" Tests

In a DC-3 Cargoliner dubbed "Sir Echo," United's radar evaluation team sampled virtually every type of weather except hurricanes and true nocturnals. In one case they flew between cells of a cloudburst so violent that it inundated railroad tracks, washed out highway bridges and put whole ranching communities under water. The Air Force weather station at Lowry Field measured 3.10 inches of rainfall in 50 minutes. The C-band radar, effectively penetrating this cloudburst, enabled the crew to follow a smooth corridor.

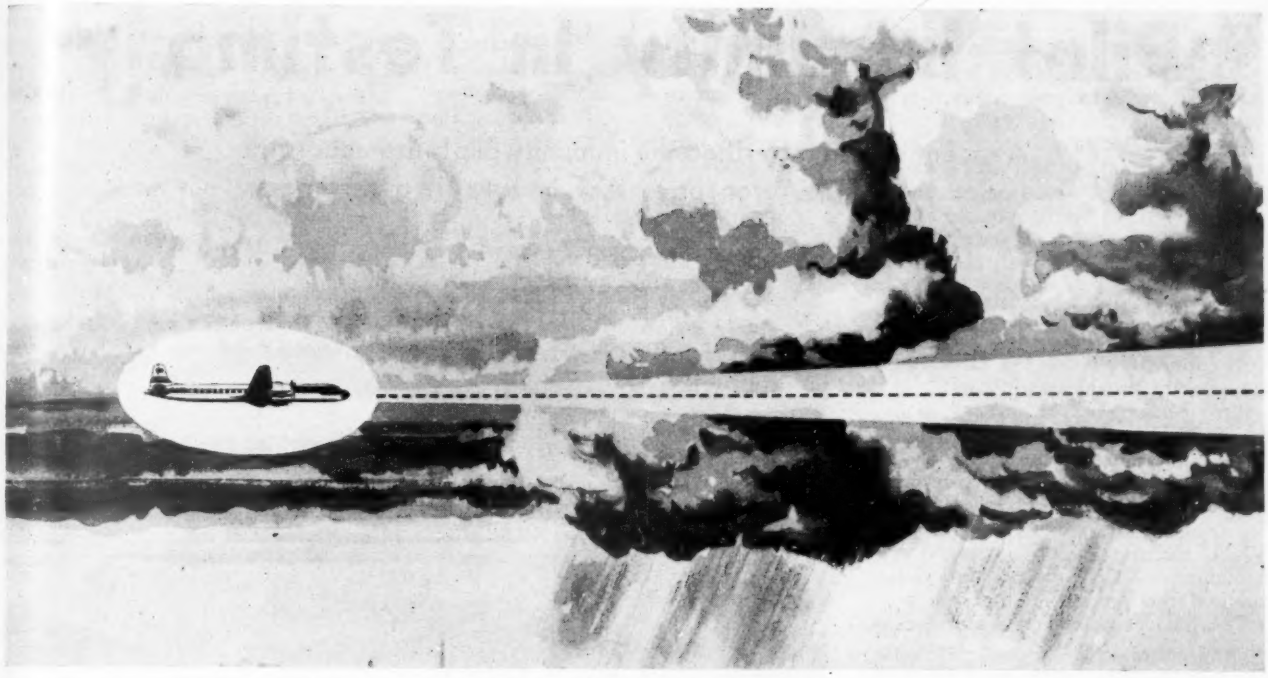
In 31 flights operated by "Sir Echo" in actual storm conditions, no instance of heavy turbulence was encountered unexpectedly and no case of hailstones of damaging size was experienced without prior warning from the C-band radar.

In current operations, the airlines have a policy of avoiding areas of heavy turbulence and hail. Under their flight plans, they use any one of a number of alternate routes to bypass such areas. With airborne radar, Cunningham said, it not only will be possible but entirely practicable to follow smooth corridors through these storms, avoiding the hard cores which will be plainly visible on the radar scope.

### Conclusions Enumerated

United's evaluation team, in enumerating its conclusions regarding 5.5 centimeter (C-band) radar, included the following:

- C-band radar is a useful device for safer, smoother navigation of thunderstorm and precipitation areas. It will permit a pilot to avoid moderate and heavier turbulence in these areas, usually by detours of five miles or less from the planned flight path.
- C-band radar will penetrate 15 miles or more of heavy rain equal to or greater than 60 mm/hour and will not lead a pilot into the hard core of a storm.
- It provides a satisfactory warning of hail shafts.



This is how C-band airborne radar is used to bypass thunderstorm turbulence. Airliner in upper sketch nears cloud formation which human eye sees as unbroken expanse. Photo of radar scope in cockpit shows same formation with storm cores clearly defined. To continue smooth flight ahead, pilot has choice of corridors indicated by dotted lines.

▸ There is considerable indirect evidence that radar will permit the pilot to avoid tornadoes merely by exercising good judgment in detouring sharp-edged echos and in being suspicious of any fingerlike projections from such echos.

▸ While the radar is intended primarily for weather mapping, its capabilities for terrain mapping are good.

▸ Radar has little, if any, application in the avoidance of other aircraft.

E. A. Post, superintendent of navigational aids for United, points out that C-band radar will permit a pilot to detour a storm area after having scanned it from over 75 miles or more away or to choose a corridor of the mildest activity or turbulence if penetration of the storm areas is desirable or necessary. He also says radar will be extremely useful in permitting pilots to scan the areas around an airport before taking off or landing to determine the best possible flight path into or out of that airport.

### Installation Next Year

"All in all," say those who developed the program, "we are confident that C-band airborne radar will prove an extremely important factor in the further development of dependable schedules and maximum passenger comfort."

United has indicated that it will place orders for C-band radar after evaluation tests are completed on production models available from manufacturers. Installation will start in the spring of 1955.

# Pilot Immunity In Testimony

**A recent decision clarified the immunity pilots are accorded under the Civil Aeronautics Act in hearing testimony.**

By F. Harold Bennett
*Head, ALPA Legal Dept.*

Section 1004(i) of the Civil Aeronautics Act provides as follows:

*"No person shall be excused . . . ."*

The Legal Department of the Air Line Pilots Association in the representation of pilots who have been so unfortunate as to be involved in an incident, in which there exists the possibility that they might be charged with violation of a Civil Air Regulation, has advised the precaution that the pilot seek whatever protection is afforded by this Section of the Act.

It is understandable, as a mark of our time, that the pilots look askance at the procedure, and are reluctant to avail themselves of it; they erroneously theorize that to do so is at once, an admission of wrongdoing, and an effort to escape the consequences.

We cannot regard it as wrongful to accept any protection which is legally afforded, nor do we feel that one can be criticized if he avails himself of a legal protection which our Congress, in its wisdom, has seen fit to provide.

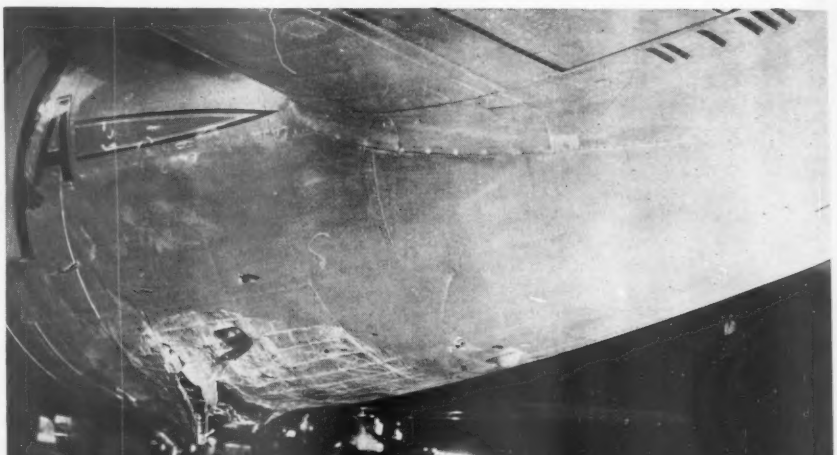
### A Rightful Protection

In any event, as the good advocate, we would be guilty of a serious omission if we failed to acquaint the pilot with all his rights and urge that he accept the Law's protection. Those conflicting concepts have resulted in a unique situation for the pilots involved in the "incident" here under discussion, as we shall see.

Previous to August 2, 1954, when the Civil Aeronautics Board rendered its decision in CAB Docket SR-2168, much confusion existed respecting the application and the protection afforded by the Section, and while there still remains the possibility of further clarification resulting from some subsequent judicial determination, since the SR-2168 was not appealed to the courts, we are in a position to report to the membership the clarification which have resulted from this litigation.

### Board's Decision

The facts in the Case and the subsequent procedures which gave rise to the single issue of "immunity" under



**TEST CASE: The Michigan City mid-air collison provided a test of pilot's right to claim his immunity in testifying before CAB.**

Section 1004(i) are recited in the Board's Decision as follows:

*"The facts giving rise to these cases are not in dispute. Respondents are pilots. On August 26, 1953, one respondent was pilot-in-command and the other respondent was copilot, of a Convair aircraft which collided in mid-air near Michigan City, Indiana, with another Convair aircraft operated by American Airlines. Fortunately, no lives were lost. A formal Aircraft Accident Inquiry followed, conducted by a duly qualified hearing officer of the Board. Respondents were subpenaed to appear and testify concerning the accident. Each claimed his privilege against self-incrimination. The pilots were directed to testify by the hearing officer, an action deemed by the Board to be within his competence, and each testified with respect to the midair collision.*

*"Susequently, the Administrator filed complaints with the Board alleging in substance that respondents had failed to exercise sufficient vigilance to observe the American aircraft and to avoid the collision, and had thereby operated the United aircraft in a careless manner so as to endanger the life and property of others, in violation of Section 60.12 of the Civil Air Regulations. The complaints charge each pilot with failure to exercise the degree of care, caution and judgment required of him, and the Board is requested to suspend each pilot certificate in the public interest.*

*"The pilots filed motions to dismiss, asserting* ***inter alia*** *that a suspension of their licenses would constitute a 'penalty or forfeiture' within the meaning of Section 1004(i), and that complete immunity therefrom had been granted by the Section in that they had been compelled to testify concerning the collision in the accident investigation. We treat the motions to dismiss as pleas in bar to the imposition of any suspension."*

### Affords Immunity

The Board finds that oral testimony required of a respondent in an Accident Investigation Hearing falls within the purview of the subject Section and entitles the respondent to whatever im-

munity is afforded thereby; in the words of the Board:

*"It (Section 1004(i)) does have application to oral testimony compelled of individual airmen and the oral testimony required of the respondents in the accident investigation is sufficiently related to the actions which form the basis of the instant proceedings to entitle them to whatever immunity the Section provides."*

### Extends to Penalties

The Board finds further that the protection afforded by the Subject Section extends to penalties imposed purely as a punishment with respect to the violation even though the action may be regarded, for all other purposes, as civil in nature; that a suspension or other sanction which may be imposed for purely "remedial purposes" is not so barred. The finding of the Board in this regard is stated:

*"We consider that a suspension of an airman certificate solely for the purpose of punishing the airman for violations of the Civil Air Regulations would constitute a penalty in the constitutional sense, and that Section 1004(i) has immunized the respondents against any suspension imposed purely as punishment with respect to the violations here alleged. On the other hand, it is clear that a suspension or other sanction imposed for remedial purposes is not barred by Section 1004(i), since the privilege against self-incrimination does not extend to remedial sanctions imposed in proceedings which are civil in nature."*

### Clarification

To make this distinction abundantly clear, the Board in its Opinion points out that if a pilot is so lacking in qualifications as to make the revocation of his license necessary, the Board in the interest of safety could revoke his license, even though he may have been compelled to testify under 1004 (i) in a proper proceeding. This clarification is stated:

*"The Board may revoke a pilot's license in the interest of safety because he is unqualified, irrespective of whether he has been compelled to testify under Section 1004(i). We think it plain that such a revocation would be remedial, and that the immunity conferred by Section 1004(i) would not extend to such an action. We think it equally plain that Section 1004(i) does not grant immunity from suspensions relating to pilot qualifications. For exemple, a pilot may be shown to be unfamiliar with applicable regulations or operating procedures, or otherwise lacking in technical proficiency. He may be suffering from temporary physical disability. Suspensions imposed until proficiency is achieved and demonstrated or disability removed obviously are remedial. We are of the opinion that such remedial suspensions may be imposed irrespective of whether the airman has been compelled to testify in that or any related proceeding."*

### Board Opinion on Penalties

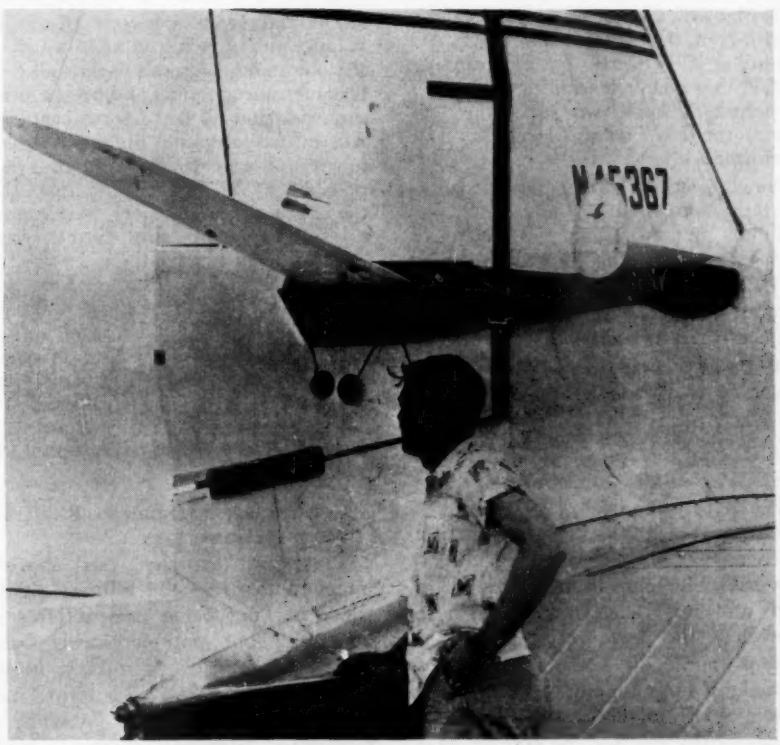
The Opinion states that the Board never imposes penalties in violation cases as punishment; that suspensions imposed in such cases are for the purpose of deterring further violations by the offending pilot and others. The Board holds nevertheless that for the purposes of Section 1004(i) no distinction may be drawn between suspensions imposed merely to prevent and deter and those which might be imposed as a penalty, and that in each instance if the immunity as provided by Section 1004(i) is properly asked, it will be granted. In the language of the Board:

*"We are inclined to the view, and hold, that suspensions imposed merely to prevent and deter violations, and where requalification in one or more respects is not involved, are punitive in the constitutional sense, and are a type of 'penalty' from which immunity is provided by Section 1004(i)."*

In deciding the Case upon the basis of its findings and determinations as above recited, the Board found that the complaint filed by the Administrator did not in terms allege the respondent to be unqualified in any respect, that a disciplinary suspension was sought, that the respondents had properly claimed immunity under Section 1004(i) and were entitled to the protection afforded thereby; the complaint against them was dismissed accordingly.

### A Result

At the Accident Inquiry Hearing, the Association represented the American pilots involved in the incident as well as the United pilots. The American pilots decided against claiming the protection afforded by the subject Section. The unique situation brought about by the Board's decision stems from the fact that the Administrator has brought exactly similar charges against these American pilots, and since they did not claim the protection afforded by Section 1004(i) they will presumably be required to meet the Administrator's case on its merits.



**ODD HAZARDS: A 6 foot model plane ploughs into rudder of a parked airliner at Salina, Kansas, with the above results.**

# A Rational Performance Concept

**Performance is a safety component. The rational method measures that part dependent on aircraft's ability to accomplish desired trajectory.**

By Captain C. C. Jackson,
*Technical Secretary, IFALPA*

1. History.

Man's first step towards science was in learning how to measure. He measured the performance of his bow by pacing the range of an arrow shot at the optimum trajectory. From that stage he has progressed somewhat until he now feels that he can attempt to apply methods of measurement to more abstract things. He feels that he can justifiably attempt to give an abstract but nevertheless reliable index to air safety, and to do this he has employed the latest theories of mathematical probability. There are possibly other ways in which air safety might have been measured, but it was agreed internationally (at the Third Session of the ICAO Airworthiness Division, 1949) that the most promising method was that provided by statistical analysis, and it is on this method that the ICAO Standing Committee on Performance (SCP) has gone ahead to develop, over a period of some two years, the "rational method" of measuring aircraft performance.

Since aircraft performance is an important component of air safety, the rational method provides a means of measuring that part of air safety which is dependent upon the ability of the aircraft to comply with the desired trajectory; it is, in its first intent, no more than a modern method of measuring trajectory.

2. Philosophy.

Although the terms of reference of the SCP were first to *measure* air safety rather than to *improve* it, some degree of improvement has always been indirectly envisaged. The duty of the SCP was not only to measure air safety in each and every stage of flight, but to show how the degree of risk involved in one stage could be so controlled as to make it approximately equal to the degree of risk involved in another; this automatically entailed the concept of a uniform level of safety throughout the flight and by that alone safety should be increased, since the tendency must always be to bring the weaker flight stage up to the level of the stronger. Similarly, the SCP has aimed at defining the over-all risk of each flight, again with the object of ensuring that the level of risk in one flight is approximately equal to the level in another. Once a uniform level of safety is agreed, it is possible to push it up or to bring it down according to the balance of forces existing between the ethical desire of a generation to conserve its life and its practical desire to move about quickly.

The exact balance has not yet been struck by the SCP; it has been left for final decision at the plenary Air Navigation Conference due to take place in Montreal in the Autumn.* The SCP, however, has provided some guidance as to the limits between which the balance might swing so as to avoid, on the one hand, such safety that all flight becomes uneconomic, and on the other, such risk that all flight is unacceptable. These two absolute limits are themselves not easy to establish, but it is possible, by taking as a reference line the existing level of safety, to determine a band between the two extremes which covers a casualty rate which is socially acceptable. This band has been determined by the SCP to range between the level at which a critical flight would have a "casualty risk" of one in a million and the level at which that risk would be ten in a million. The basis on which the figures have been determined is given in paragraph 9 (see page 12.)

3. An Incident, Incident Rate, Incident Probability.

The word "casualty" used above is intended to carry the military significance of "not being present after an operation, but not necessarily being wounded or dead." Similarly, in the language of the SCP, the term "incident" is used to denote "absence of required performance during a flight operation"; it does not imply a positive accident. From now on it is proposed to use the word "incident" rather than "casuality."

By way of example, a flight incident is said to occur if the scheduled minimum safe flight level over a particular sector is 15,000 ft., but due to poor performance on the day in question, the aircraft can achieve only 14,000 ft. There is 1,000 ft. "absence of required performance," but not necessarily an accident. Whether or not there is an accident depends on the terrain and the accuracy of the navigation at the time.

It is important to distinguish between "incident rate" and "incident probability." The expression "incident rate" would imply (assuming the acceptable figure to be one incident per 1,000,000 flights undertaken) that after 999,999 safe flights it would be permissible to take off on a flight on which it was certain that an incident would occur. However, the philosophy of the rational concept (see 2 above) demands that each flight must be as safe as the others; the one millionth flight must be as safe as the other 999,999—that is, it must carry an incident *probability* of one in a million, not an incident *rate*. That is why we must distinguish between incident probabilities and incident rates.

The "design incident probability" is the (very small) probability accepted in the design of the aircraft that it will not have the required performance.

4. The Datum.

The datum is the flight path below which the aircraft should not, by reason of lack of performance, be brought except on the occasions allowed by the design incident probability. It consists usually of an obstacle clearance plus a small amount to allow for ability to manoeuvre. For example, on take-off the datum is an obstacle clearance at the end of the runway of 20 ft., which includes a certain amount for missing the obstacle and a smaller amount to allow for the height which might be lost due to the effect of small corrective turns.

5. The Margin.

The idea of a margin is simple

*Now probably postponed till 1955.

enough. It is merely an allowance for the factors affecting aircraft performance which it is difficult to provide for by varying the operational weight of the aircraft. Some variables affecting performance (e.g., temperature, humidity, wind component, atmospheric pressure, runway slope) can easily be allowed for when calculating the maximum permissible take-off weight. They are not, therefore, included in the margins. On the other hand, such factors as the variability of engine power, propeller efficiency, airframe drag, etc., cannot be easily allowed for on a day-to-day basis and so are dealt with by an over-all safety cushion or "margin," built into every flight stage.

The margin can be expressed in terms of the all engines operating, one-out, or two-out, performance (the value, of course, will differ according to which is chosen) and takes into account the probability of these various conditions occurring.

6. The Variability of Performance.

6.1—From paragraph 5 it will be clear that we need to know the way in which performance varies between nominally identical aeroplanes and from day to day on the same aeroplane (after correction for operational factors such as weight, altitude and temperature).

This has been assessed firstly by calculation, and secondly by tests.

6.2—*Assessment by calculation.*

The effect of individual variables, such as airframe drag, basic engine power, instrument errors, unintentional sideslip, etc., has been estimated, using test results where possible. The variations from these individual sources are combined, and a total variation deduced.

6.3—*Assessment by test.*

As a check on 6.2 the performance on aeroplanes is measured, and its variability deduced. This is an important function, but not the only one, of the climb performance tests required for the renewal of a Certificate of Airworthiness.

6.4—*The form which the variation takes.*

Figure 1 shows a typical set of test results.

It will be seen that these results fit quite closely (considering that it is a limited sample) to a "normal frequency distribution curve" which is the distribution which would result from random variations about a target. Such a curve may be tall and narrow, if the variation is small, or low and flat, if the variation is large, but they all follow the same basic formula, which has one very useful property which simplifies their use enormously. This property is that the shape of the curve can be uniquely defined by its "standard deviation" and that, therefore, the probability of getting a performance of "t" or more standard deviations below the mean can be immediately ascertained by reference to standard probability tables, an extract from which is given in Appendix A.

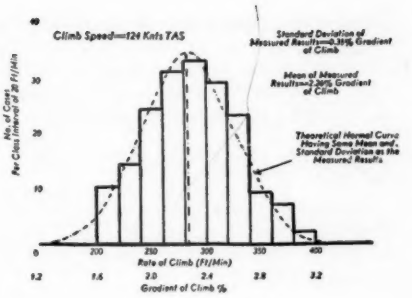

Climb Speed—124 Knts TAS
Standard Deviation of Measured Results=0.35% Gradient of Climb
Mean of Measured Results=2.26% Gradient of Climb
Theoretical Normal Curve Having Same Mean and Standard Deviation as the Measured Results
No. of Cases Per Class Interval of 20 Ft/Min
Rate of Climb (Ft/Min)
Gradient of Climb %

Figure One

6.5—*The normal frequency distribution curve.*

The "normal curve" of Figure 1 is reproduced again on its own in Figure 2.

It will be noted that it is symmetrical about the mean and that, theoretically, it meets the base line (zero frequency) at infinity (i.e., off the page). In practice, of course, it approaches the base line so closely after a short distance that it is not possible to draw the two lines separately.

It will be seen from the table that the area under the curve to the left of line XX which marks the standard deviation is 0.159 of the whole area under the curve, i.e., about 16%. This means that when the mean performance is 2.26% and the standard deviation is 0.35%, the chance of getting a performance as low, or lower than 1.91% is about 16 in 100. Similarly, the probability of getting a performance of 1.56% (2 standard deviations below the mean) is 0.0227, i.e., about 2 in 100.

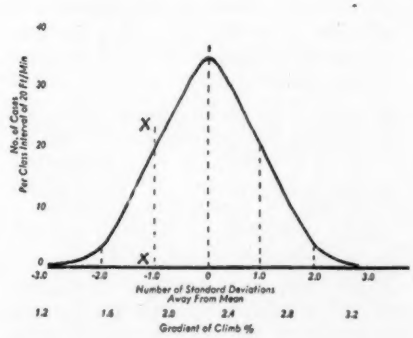



Figure Two

Conversely, let us suppose that we want the chance of having a gradient of less than 2.8% after deliberately stopping one engine to be not more than 1 in 1,000 ($10^{-3}$), and that the standard deviation is still 0.35%. For a probability of $10^{-3}$ (0.0010) we find that a margin of 3.09 standard deviations is required, i.e., the aeroplane must have a mean gradient of climb of $[2.8+(3.09\times0.35)]=3.88\%$. In terms of Figure 2 the aeroplane must be unloaded so that the curve moves across the page to a point at which its mean is equal to 3.88%.

We are thus able, once the standard deviation is known, to derive a margin given the incident probability, and vice-versa, for a deliberately selected number of engines operating.

The effect that chance plays in selecting the number of engines operating must, however, be looked after in practice: the way this is dealt with appears in the next paragraph.

7. Determination of Incident Probability, Given the Performance

7.1—*Numerical illustration.*

The total incident probability for a given stage of flight (e.g. take-off, en route, or landing) is the sum of the probabilities of having an incident in each of the cases which can arise. On a four-engined aircraft these are: all engines operating, three engines operating, two engines operating, etc.

i.e.

$$Q=P_0+P_1+P_2+P_3+P_4$$

where,

Q is the desired incident probability

$P_0$ is the contribution, to the total risk, of the all engine operating case.

$P_1$ is the contribution, to the total risk, of the one-engine-out case.

$P_2$ is the contribution, to the total risk, of the two-engine-out case.

etc.

One can usually ignore $P_3$ and $P_4$ in performance requirements, since it is clear that the three-engines-out or four-engines-out cases occur so rarely that they contribute a neglible amount to the overall risk.

Now each of these P's is the product of two probabilities, namely $p_c$, the probability of the case occurring at all, and $p_1$, the probability, when the case has occurred, of the performance being below the datum value.

7.1.1.—$p_c$, *the probability of the case occurring.*

$p_c$ is fairly simple to calculate once the probability of an engine failing is known. Let us suppose that the aeroplane has four engines and that the

probability of a particular engine failing is 1 in 4,000.

There are four engines, so the total chance of having the one-engine-out case is

$$4\times\frac{1}{4{,}000}=\frac{1}{1{,}000}=p_{c1} \quad . \quad . \quad . \quad . \quad (i)$$

The chance of a particular pair of engines failing is $\left(\frac{1}{4{,}000}\right)^2$.

In four engines there are six different possible pairs, so the total probability of having the two-engine-out case is

$$6\times\left(\frac{1}{4{,}000}\right)^2=\frac{.375}{1{,}000{,}000}=p_{c2} \quad . \quad . \quad (ii)$$

The probability of having all engines operating is one minus the probability of having one or more engines out, i.e.

$$1-\left(\frac{1}{1{,}000}+\frac{.375}{1{,}000{,}000}\right)=0.998625,$$

say $0.999=p_{c0}$ . . . . (iii)

if two engines are inoperative

$$\text{(iii)}\quad \frac{1}{10{,}000{,}000}=p_{i0}$$

if all engines are operating

7.1.3—*Q, the design incident probability.*

Multiplying the values of $p_c$ and $p_i$ obtained from paragraphs 7.1.1 and 7.1.2, for use with the main formula of paragraph 7.1, we get:

$$P_0=0.999\times\frac{1}{10{,}000{,}000}=\frac{.999}{10{,}000{,}000}$$

$$P_1=0.001\times\frac{96}{10{,}000}=\frac{96}{10{,}000{,}000}$$

$$P_2=\frac{.375}{1{,}000{,}000}\times.9848=\frac{3.693}{10{,}000{,}000}$$

thus $Q=P_0+P_1+P_2=\frac{.99+96+3.693}{10{,}000{,}000}$

$$=\frac{100{,}692}{10{,}000{,}000}$$

dominant case. (The two engines-out case may be dominant in the en route requirement for long flights.)

7.2—*Pictorial illustration.*

The process described in 7.1 may be visualised with the aid of Figure 3, which illustrates diagrammatically the relationship of the three cases.

In this Figure, normal curves of gradient of climb versus frequency of occurrence (for all-engines-operating, one-out, and two-out, respectively) are superimposed: each point on the heavily drawn envelope representing the total frequency of occurrence of a particular level of performance, i.e., the sum of the frequencies contributed by the all-engines-operating, one-out, and two-out cases.

The shaded area to the left of the line $XX^1$ is the probability of the performance being as low as, or lower than, the datum performance; i.e. below the pilot's rock bottom minimum needs.

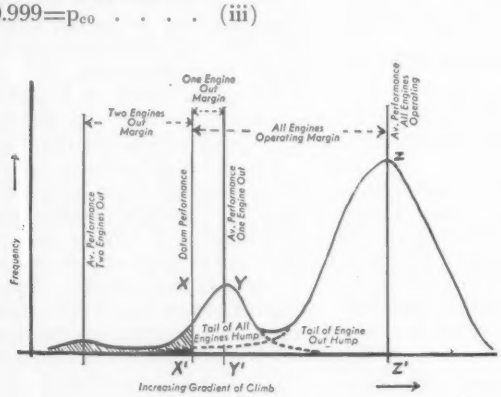



Figure Three

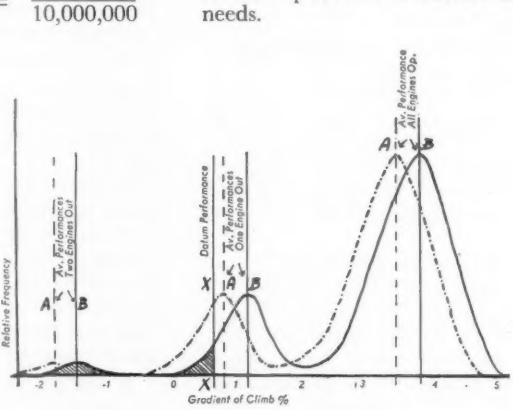



Figure Four

It is of interest that the sort of mathematics used above was developed by the French author and mathematician Pascal in the 17th century, to assist his friend Chevalier de Mere in has gambling activities.

7.1.2—$p_1$ *The probability, in the case considered, of the performance being below the datum value.*

This is obtained by finding the number of standard deviations separating the datum from the mean performance with the number of engines operating which is being considered, and consulting probability tables, as explained in paragraph 6.

For this example, let us assume that the probabilities of the performance being down to the datum value are

$$\text{(i)}\quad \frac{96}{10{,}000}=p_{i1}$$

if one engine is inoperative

$$\text{(ii)}\quad \frac{9{,}848}{10{,}000}=p_{i2}$$

which is near enough $\frac{1}{100{,}000}$ or $10^{-5}$.

This is, incidentally, the design incident probability at present aimed at in British certification.

It is seen that the probability of an incident arises chiefly from having one engine out, and this in fact is the normal case. This is because:—

(*a*) with all engines operating the performance rarely falls to a dangerous level; and

(*b*) with two engines inoperative, although the performance would almost certainly be at a dangerous level, the chance of two engines failing is practically negligible—the combined result being a small contribution to the total risk.

The case (i.e., number of engines out) which clearly contributes the major portion of the risk—in this example the one out case—is known as the

It will be seen that the area under that part of the all-engines hump which is to the left of $XX^1$ is only a small part of the total area to the left of $XX^1$.

You will remember that in paragraph 7.1.3 the contribution of the all engines case was small. Similarly, although the two-engines-out hump is nearly all to the left of $XX^1$, its whole area is small compared with the part of the one-engine-out hump to the left of $XX^1$. This lines up with the small contribution of the two-out case shown in paragraph 7.1.3.

It is also noticeable that the datum performance line passes through the "hump" of the dominant case.

7.3—*Quick methods of calculating incident probability.*

Where the humps are well separated and the contributions of the non-dominant cases are therefore small (as is usually the case), a fair idea of the

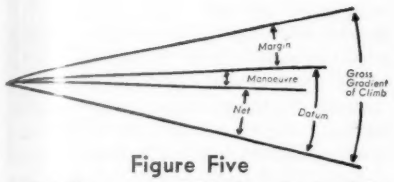



Figure Five

probability can quickly be obtained by ignoring the non-dominant cases, i.e. in this example, to assume that $Q=P_1=P_{c1}\times p_{11}$.

Given the engine failure probability, the standard deviation of performance, the gap between the desired datum and the average performance, and a set of ordinary probability tables, this is a sum anyone can do, having read paragraph 6.

A useful refinement to the above, which adds considerable accuracy for a very small increase in calculation, is when the one-out case is dominant, to put $p_{12}=1$, which makes $P_2=p_{c2}$, which can be easily calculated. As before, the all-engines case would be ignored, i.e. $p_{10}$ is assumed to be zero.

These quick methods are, however, not suitable when there is considerable overlap between the humps (as when there are many engines), or when certain other subtleties have to be considered, as is the case in some requirements.

7.4—*Stage incident probability and Flight incident probability.*

Except where two sub-stages are deliberately balanced against each other (e.g. continued take-off and accelerate-stop), it is fairly safe to assume that only one stage is critical in a given flight. It can be shown that a stage does not have to be very un-critical before its contribution to the total risk can be neglected, just as the contribution of the non-dominant *cases* can be neglected in the simple climb example. (Note the special meaning which is attached to "case" as distinct from "stage.")

## 8. Determination of the Performance Required, for a Given Incident Probability.

8.1—In paragraph 6 we dealt with the problem of assessing the risk associated with a given level of performance. Let us now consider the inverse of this, namely "how much performance margin do we need to hold the risk down to a given level?"

Let us consider a simple requirement, say, the initial en-route climb for a four-engined aeroplane.

8.2—*Assumptions.*

First, let us choose our datum, say +0.5% gradient of climb, plus, for manoeuvre performance, a steady 8 deg. banked turn, which requires a further 0.15% gradient (there are also sundry detailed conditions, e.g. height above the aerodrome of take-off, satisfactory engine cooling, etc., which it is not proposed to go into now): i.e. a total datum of +0.65% gradient of climb.

Then, let us choose our incident probability, say $10^{-5}$.

Assuming a typical relationship (which can be calculated) between the all-engines-operating, one-out, and two-out performances, suitable standard deviations of performances (see paragraph 6.4) and an appropriate engine failure probability, an envelope curve similar to that in Figure 3 could be drawn, having the right shape but, as yet, no defined position relative to the datum performance.

8.3—*Determination of performance required.*

Our job now is by adjusting aeroplane weight to slide this curve (AAA on Figure 4) sideways, across the line XX (representing the datum performance) to a position BBB where the area under the curve to the left of XX is $\frac{1}{100,000}$ of the total area under the curve.

If we knew the correct relationship for the particular aeroplane between the average performance with all engines operating, one-out, and two-out (which would imply testing in each configuration), we could then state the required performance either as an all-engines gradient of +3.85%, or a one-out gradient of +1.15%, or a two-out gradient of —1.57%, the corresponding margin values being 3.2%, .5%, and —2.22% respectively (i.e. gradient less datum of +0.65% in each case).

It is, however, inconvenient to test in all three configurations (with sufficient thoroughness to get the exact relationship) so the requirement is usually specified, and the aeroplane tested, in the configuration of the dominant case. Since the contribution of risk from the non-dominant cases is small, the error due to not knowing the exact relationship is acceptably small. By contrast, it *is* important that the performance in the configuration of the dominant case be accurately established, and the proper emphasis be put on any special characteristics e.g. engine cooling, or ease of control, which affect that case.

The process described above of sliding the curve would be rather clumsy to carry out physically, so in practice the operation would be performed by calculation, i.e. by using the formula of paragraph 7, namely $Q=P_0+P_1+P_2=(p_c\times p_1)$ all operating $+$ $(p_c\times p_1)$ one-out $+(p_c\times p_1)$ two-out.

Inserting the values we know, we get

$$10^{-5}=\left(.999\times p_1 \text{ (all-operating)}\right)+\left(\frac{1}{1,000}\times p_1 \text{ (one-out)}\right)+\left(\frac{.375}{1,000,000}\times p_1 \text{ (two-out)}\right)$$

Since the three $p_1$'s are related to each other through the performance relationship, this equation can be solved.

8.4—*Quick method.*

As in paragraph 7.3 it is possible (by ignoring the non-dominant cases) to save time without noticeable loss of accuracy. Thus, by making the reasonable approximation in the equation of 8.3 that

$$p_{10}=0$$
$$\text{and } p_{12}=1$$
$$\text{we get } P_0=0 \text{ and } P_2=p_{c2}$$
$$\text{and } Q=P_1+P_2$$

$$\text{i.e. } 10^{-5}=\left(\frac{1}{1,000}\times p_1 \text{ (all out)}\right)+\frac{.375}{1,000,000}$$

$$\text{or } p_1 \text{ (one out)}=\left(\frac{10-.375}{1,000,000}\right)\times 1,000=0.009625$$

Reference to Appendix A shows that for $p_1$ to equal 0.00963 the mean performance (with an engine out) must lie at about 2.34 standard deviations above the datum of .65% assumed in 8.2. If the standard deviation is 0.35% gradient of climb, this margin must thus be 0.82%, and the total requirement (margin and datum) must be .82%+.65%=1.47% say 1.5%.

8.5—*Common terms.*

The concepts of Datum and Margin have already been given (paragraphs 4 and 5) but before leaving them, it is desirable to introduce three additional terms used by the SCP with particular connotations:—

(1) *Gross Performance* is the performance of an aircraft as computed on the assumption that all the factors which might affect its ability to meet

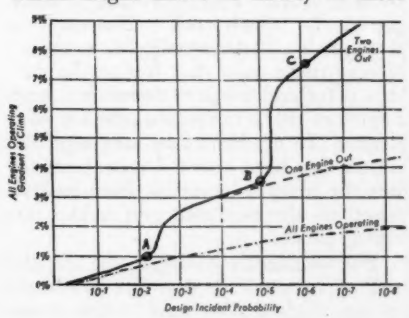



Figure Six

a particular performance requirement have their average values.

(2) *Net Performance* is the performance of an aircraft when all the margin and any manoeuvre performance have been eaten up.

(3) *Manoeuvre Performance* is the gradient of climb needed in straight flight, if the aeroplane is to be able to make a steady turn in level flight at a defined angle of bank, e.g. 8 deg.

The relationship of these terms is illustrated in Figure 5.

8.6—*Gross performance.*

It will be apparent that one of the key assumptions in computing requirements on this system is that the gross performance assumed in compiling the Flight Manual shall not be worse than the mean of the fleet averaged over the period of validity of the Flight Manual. This is another important reason for the performance tests called for by British Authorities as a condition of the renewal of certificates of airworthiness (the first reason was given in paragraph 6.3). The third reason is to limit the time for which a particular aeroplane can be a "rogue" and remain undetected. These precautions are, of course, supplementary to the efforts made to adjust prototype test results to estimated "fleet average" conditions wherever necessary.

9. The Selection of a Tolerable Design Incident Probability.

In paragraph 7.1.2 above we arranged our margins so that the design incident probability came out at $10^{-5}$. What is the significance of this figure? The human mind has difficulty in grasping the significance of numbers much above 1,000. It may, therefore, be worthwhile to use an analogy.

It is the practice of water engineers in the United Kingdom to plan their reservoir supplies by utilising the theory of probability. They assume a normal distribution of rainfall over a period of years and aim at providing sufficient storage capacity so that a drought as long as the longest known drought is unlikely to occur except once in seven to ten years. This is clearly a comparatively high risk. However, a drought is not necessarily calamitous—it may mean only that hosing the garden is forbidden—and therefore a high degree of risk is not necessarily a serious degree. In mathematical language, the datum has been selected conservatively but the margin is narrow because it is based on the acceptance of a high incident probability.

But we cannot afford, in the air, the risk of an incident once in every seven to ten flights. We have selected our probability to give an incident only once in 100,000 flights. If the longest drought were 73½ days (.2 years), this is 1/2,000 of the water engineer's risk; or, conversely, if he applied the same standards as the aircraft designer, it would mean that one could not hose the garden approximately once in 5,000 years.

That is the sort of safety aimed at in the design of an aircraft—the tolerable design incident probability.

Why has this particular order of risk been considered acceptable in air transport?

The probability of an incident may be influenced by many factors, but it is not difficult to see that the major influence is that of engine failure. This is shown clearly in formula just used for calculating the margin (paragraph 8.4).

In commercial air transportation we are not prepared to accept an incident every time an engine fails; for that reason single-engined aircraft are unacceptable. But we are prepared to accept the failure of one engine of a twin engined aircraft, provided that it can maintain a safe flight path to a suitable aerodrome. On the other hand, we do not think that a twin engined aircraft should fly too far over the sea since, once it has lost the first engine, it becomes a single-engined aircraft and the possible loss of the second engine becomes important. In the case of a four engined aircraft, we expect it to cope comfortably on three engines, but we are prepared to accept, if it should lose a second engine, a very small margin of safety over that required to gain a suitable aerodrome.

From the above it will be seen that we have quite definite ideas on what is a reasonable risk—a tolerable design incident probability—and what is not. These ideas are capable of more or less accurate mathematical expression. This is shown by the graph given in Figure 6, but before studying this it may be appropriate to recall the remarks of Laplace (1820):—

> "We see . . . that the theory of probabilities is at bottom only common sense reduced to calculations; it makes us appreciate with exactitude what reasonable minds feel by a sort of instinct, often without being able to account for it . . .
>
> It is remarkable that (this) science, which originated in the consideration of games of chance, should have become the most important object of human knowledge."

In the graph of Figure 6 it will be seen that (assuming a datum of "level flight") to increase the ability of the aircraft to climb with all engines operating from 1% to 2.5% has very little effect on the incident probability, which remains within the 1/100 and 1/1,000 bracket; however, by increasing the climb gradient from 2.5% to 3.5% the incident probability comes down to 1/100,000—i.e., a hundredfold decrease of risk (increase of safety). The reason for this is that at an all engines climb gradient of 3.5% the aircraft has sufficient "climbability" in hand to be able to cope after failure of an engine.

After the 3.5% gradient is reached (where the aircraft can cope with one engine inoperative) there is again a period during which any increase in the gradient will have very little effect in increasing safety; this period lasts till a gradient of 7% is reached, at which point the aircraft can still cope even after the loss of two engines and the incident probability is reduced further to 1 per million or less.

From this will be seen that the choice of an acceptable design incident probability must, for economic reasons, be made so that the corresponding climb margin is as low as possible, provided that the aircraft maintains the performance necessary for it to comply with the requirements stated at the beginning of this section. That is, ideally, the design incident probability will be that corresponding to the bottom of one of the steps in the graph—e.g. point A or B. There is no advantage in asking for a slightly higher

## Appendix A.

### Extracts From a Table of Normal Distribution

| "t" (Standard Deviations) | Probability of deviation exceeding "t" in one direction. | |
|---|---|---|
| 1.00 | .159 | |
| 1.28 | .100 | $10^{-1}$ |
| 2.00 | .0227 | |
| 2.33 | .0099 | $10^{-2}$ |
| 2.4 | .0082 | |
| 3.09 | .0010 | $10^{-3}$ |
| 3.71 | .0001 | $10^{-4}$ |
| 4.26 | .00001 | $10^{-5}$ |
| 4.75 | .000001 | $10^{-6}$ |
| 5.2 | .0000001 | $10^{-7}$ |

With acknoweldgements to the members of the ICAO Standing Committee on Performance and others who, in some 200 working papers, have laid the foundation stones of a new science—the science of air safety.

climb gradient, since, as we have seen, this does not result in any appreciable increase in safety—at any rate until the stage is reached at which the aircraft would climb after losing a further engine. All that would be achieved would be a decrease in payload with no corresponding increase in safety. So, in practice, the choice of an incident probability has centered on the section of the graph which lies between the climb gradient which would easily take care, at the one extreme, of the one-engine-out case and, at the other extreme, just take care of the two-engine-out case—i.e., the section BC. It will be seen that this corresponds to a design incident probability of between 1/100,000 and 1/1,000,000 ($10^{-5}$ and $10^{-6}$).

10. Engineering Implications.

It has been shown in paragraph 9 how important are the assumptions made with regard to engine failure rate. In this field there has been considerable controversy, but, if a performance code is to mean anything in relation to air safety, it must be a code which exerts its influence not only during the certification tests of the prototype but an influence continuing throughout fleet operations. There is thus an obligation to relate the engineering approach (which attempts to provide reliability) with the performance approach, which must assume some definite standard of reliability.

This focus on reliability, which is provided by the rational approach, is not restricted to the engine failure rate: its implications may extend to many less obvious fields, such as the provision of essential services after engine failure, the reliability of brakes, the ease of touching down in emergency at speeds higher than normal, the evaluation of runway slipperiness. Thus its value is not to be measured merely in the elimination of weak spots in the performance spectrum, but in the pointers which it gives to efficient design in the sense of obtaining maximum payload and minimum field lengths without prejudice to an adequate, definable, and clearly understood, level of safety.

## 13 Biennial Convention

*The ALPA Convention will be held at the Shoreland Hotel, Chicago, November 8-13. The Banquet will be held the evening of Thursday, November 11.*

# Bert Acosta Is Dead

**By Paul Harvey**

*NBC News Analyst*

*How you want to remember him is up to you.*
*I could remember him being showered with confetti and ticker-tape in a hero's parade down Broadway in 1927 . . .*
*Or I could remember him sick and broke and hinting for a handout on a Chicago street three years ago.*
*Bert Acosta was flying when he was fourteen.*
*His first airplane he made with his bare hands.*
*In his teens!*
*He was a flight instructor in World War One.*
*Flew the Mail.*
*Set a speed record in 1921, then an endurance mark.*
*Flew the Atlantic one month after Lindbergh . . . almost.*
*He swam ashore in France.*
*And then that triumphal return to New York and the big parade down Broadway.*
*But Bert's insatiable hunger for speed finally threw him off balance.*
*And things began to go sour.*
*Lost his pilot's license for stunting. Lost his wife.*
*Abandoned his second wife and their two children. And for a while he was in and out of jail for desertion.*
*Bert Acosta went to Spain to fly for the Loyalists, but not for long.*
*Came back . . . and dropped out of sight . . .*
*Until some of us saw him that day in Chicago. I was writing for Flying Magazine and Bert wanted to know couldn't he sell his story for the price of a few meals.*
*Some of us who remembered saw that he got the few meals but we didn't want to tell his story . . .*
*We didn't want to wipe away the exciting legend the great Acosta had written across the sky.*
*But then two years ago he collapsed on a New York street . . .*
*Penniless . . . ravaged by tuberculosis . . . and with cancer coming on.*
*There's a Jewish Consumptive Relief Society Sanitarium outside Denver . . . and they sent him there.*
*And that's where the end came late yesterday.*

*So how do you want to remember Bert Acosta . . .?*

*The boy building an airplane in a barn . . .*
*The hero . . . hailed on two continents . . .*
*Or the emaciated sixty-year-old has-been who begged on the street and died in a charity ward.*
*Well, I'll tell you my choice . . .*
*I'm going to remember 'em all. Because they were all part of the composite man who first gave us wings.*
*If the Bert Acostas had been men of conservative mein and mild-mannered behavior patterns . . . the airship would still be on the drawing boards.*
*The very dashing, headlong, headstrong, adventurous spirit of such as he . . . gave safer wings . . . to you and me.*
*So don't let history erase one line from the true story of Bert Acosta.*
*For where most of us may plod the beaten paths . . . these men must brave the dark and unknown forests on either side . . . and even try the sky.*
*For the Bert Acostas . . . are the reckless . . . frantic souls . . . who plunged in and pioneered the uncharted air ocean . . . while saner . . . lesser men . . . watched from the shore.*

# The Air Safety Challenge

*(Continued from Page 3)*

whether the man is manager, pilot, mechanic, builder or designer—complacency has no place in his work. Yet the very fact that a good job is being done in accident prevention will tend to lull a man into this sense of complacency. This is human, and to counteract it, we must approach the human aspects of the problem.

### Clashing Orders

An example of the lack of awareness of the problem of flight safety may be cited where the management of an airline has issued one directive, ordering employees to keep the matter of safety foremost in their minds; and at the same time issued what amounted to punitive regulations requiring on-time performance.

The man at the end of the line—the pilot or mechanic, or the station manager—must know that safety is foremost, but he is under pressure to get the airplane out on time. What does he do under these circumstances?

Sometimes what may seem like a minor consideration, such as the relocation of safety equipment in the airplane, may be a key to greater safety. For instance, the shifting of life rafts nearer the door where they are more readily accessible for ditching. It is easy for management to say: "We have run this line for so many years without trouble, and we're going to keep on doing it the way we have been doing it." In one case that came to our attention, a minor official of an airline answered an airline pilot with the statement:

"We haven't had a crash in seven years, so why bother?"

### A Governing Factor

Men down the line are naturally governed by top management's attitude. They have a sixth sense which recognizes the fine line of difference between what the boss says, and what he means. The beginning of flight safety must start at the top. Safety problems dealt with at the operating level can only be solved with the support of top management.

The increasing record of safety in the airlines indicates that this philosophy of top management generally prevails, but it must continue to grow until every source of complacency is rooted out.

Where complacency or unawareness persists, accidents will occur. It is axiomatic that there would be no preventable accidents if those who could prevent them knew they were going to happen.

We do not know how many preventable accidents occurred because of some hidden factor, which never reached the light of day because there was no place for the pilot or crewman to tell the story without the risk of prejudicing his career.

### A Tremendous Concern

Probably no other industry has so many organizations interested in trying to promote its safety. There are federal, state and municipal organizations. Organizations of private pilots, business pilots, airline pilots. Organizations of scheduled air transport operators, non-scheduled transport operators and aircraft manufacturers. All of these play a very important part in furthering the economic and technical progress of the particular segment of industry with which they are concerned. They are tremendously concerned with safety.

However, none is completely independent. Each has its own interests to defend and protect. One might say that the federal agencies represent all phases of aviation. But the federal agencies, rightly or wrongly, are considered prosecutor and judge. The conflicting interests of all segments of aviation direct their safety contentions, often at odds one with the other at the federal agencies. The result is extreme caution to take action for fear of offending or causing trouble for one segment or another.

### A Unique Position

The Flight Safety Foundation and its Cornell-Guggenheim affiliate occupy a unique position in this welter of activity. Without duplicating the activities of any of these, it enjoys a freedom of action and independence of action which is denied an industry association or a governmental agency. It also is in a unique position to act across international boundaries so that safety lessons learned, say in Australia may be applied in Canada or the United States. Above all it enjoys the confidence not only of the executives but also of the pilot and the mechanic.

When the idea of the Flight Safety Foundation was first introduced, the primary objection to such an organization was that it might "talk at the wrong time"—perhaps disclose information about the cause of an accident, and cause planes to be grounded. One airline executive said in so many words: "We can't support you, because you might knock our planes out of service." And manufacturers who were approached for support told us: "Your organization might obsolete our equipment."

### Integral Part of Industry

The very objections raised to the formation of the Flight Safety Foundation and its sister organization sponsored by Harry Guggenheim, are the best reasons for its existence—and the fact that it is a strong integral part of the aviation industry today is the best answer to the objections made at its inception.

For example, there was a case of a pilot who had not flown a route for a considerable time. The weather was down to minimums. He had never flown with the co-pilot before and the co-pilot had never flown this route.

He told the Flight Safety Foundation of this situation, and as a result, steps were taken by the airline to prevent any future assignment of pilots unless the pilot or co-pilot had flown the route recently. The pilot's name was not disclosed, and nobody lost his job because preventive medicine was applied.

### Accidents Are Costly

Accidents are expensive—not only to human life, which is the primary consideration, but to the companies which fly airplanes, and to those who make them.

There is no single segment of the industry that is competent to take care of all interests involved in flight safety. That is why the Flight Safety Foundation was organized, and why it has continued to grow and develop in spite of

## ARBITRATION

Employer can't change job content without negotiating change with union. So ruled the arbitration board in the Nebraska Consolidated Mills case, 22 LA 785. Employer did not have right unilaterally to effect substantial change in content on one job by adding duties of another job which had been partly eliminated by technological improvements and certain new duties and responsibilities resulting from those technological improvements, despite fact that there is no specific contract provision requiring negotiation on changes in job content, since it is implied condition of contract that there will be reasonable stability in content of job classification. Employer's contention that action was incidental to technological changes and therefore fell within right reserved to management to introduce new production methods and facilities is rejected; rights of management do not include right to "obliterate classification boundaries."

some of the early fears that it would "talk out of turn."

It is the logical organization to approach the problem of flight safety with complete objectivity. It has no axe to grind. It is part of the aviation industry—and the various segments of the industry participate in its activities. But it is not dominated by any segment of the industry. And therein lies its greatest value to everyone who is interested in flight safety — and that means *everyone*.

### A New Area

A whole new area of safety problems has arisen in a form which for a better name we shall call Sociological Relationships. I do not use the term employer-labor relations because it goes further than that. It includes relations between Captains and their crews, between flight crews and ground crews, between traffic departments and maintenance departments, between the pilots and the medical examiners, between pilots and management.

The free expression of fact and opinion by flight crews involved in a near accident is inhibited because someone stands poised to pounce upon them. Pilots recently pleaded immunity in their defense after stating the events leading up to an accident, which led to action by the CAA.

This has not been the fault of the pilots—although it is easy to assess the blame against them for lack of the moral courage to "stand up and be counted." But there are a lot of people besides pilots who ought to "stand up and be counted."

### Hope Isn't Enough

If we are to face the challenge of flight safety, we have got to face it all the way. It isn't enough merely to hope for the best. We've got to achieve the best that is humanly possible. The only antidote to this aspect is that a man must live with his conscience; some way must be found to provide a confidential outlet so that all the facts can be ascertained and constructive action may be taken without prejudice to the persons concerned.

Safety procedures and safety gadgets are important to aviation. But safety attitudes are vital. I agree with Dr. Kenneth Andrews of the Harvard School of Business Administration that the good health of any organization lies in the development of proper attitudes of loyalty as well as craftsmanship. This does not occur unless the various members of the organization realize that they have a common goal which is just as much the objective of a mechanic as of the head of the airline.

But this goal is a two-way proposition. Ideas and the free expression of opinion between people in an organization must flow freely, up as well as down. Morale cannot be high when large parts of an organization feel misunderstood. Good organizational health, which in turn would mean a reduction in safety problems, is best developed when everybody is at least willing to listen to everybody else.

This, of course, is difficult when animosities interfere with cockpit cooperation or when strife exists between members of different unions, for example. Here I offer for solution, inadequate as it may be: the force of public opinion, the public must be assured that safety is not being jeopardized by internal differences and misunderstandings.

### Human Problems

Another problem in human relations is the pilot's relation to medical examiners. There appear to be a number of ambiguities here that deserve exploration. What is the relation between chronological age and physical age? Are the present medical criteria really fitted to the job of flying, or are they based on old concepts that research would find inconsistent with actual practice—such as hearing? If a pilot can hear his radio and conversation in the cockpit above the noise of engines, what difference does it make to the proper fulfillment of his job if he cannot hear a whisper in a quiet room?

Human problems also involve both the engineer and the designer. While some pilots and mechanics may not think so, engineers are human. The fascinating field of engineering the cockpit and maintenance to reduce complexity and stimulate efficiency is a science as yet strange to most engineers. It involves taking into account human capabilities and limitations both physiological and psychological. Engineering for human use! You see the lack of it in your cars when your wives must peer through the spokes of the wheel to read the speedometer.

Hundreds of accidents have occurred in aviation and continue to occur because a pilot pulls the lever for the undercarriage when he meant to pull the flaps. A vast amount of data exists that would help the engineer design for human use. But it is in terms that only a psychologist or a doctor can understand, and except for the work of the Cornell-Guggenheim Center, there is no constant prodding of the engineers to seek out what facts are already available in a language he can understand. Management has a responsibility here. A few manufacturers have begun to apply the data in their designs, but much more remains to be done in this field of human engineering.

### Conclusions

In a very brief sketch, I have tried to cover the essential elements of the "Challenge of Air Safety," particularly as the challenge is directed toward human factors and human nature, rather than technical aspects of safety.

- The entire problem can be summarized in a single sentence, which is the creed of the Flight Safety Foundation: Flight Safety is everybody's business!
- You cannot legislate safety, and you cannot enforce safety measures, by the application of legal persuasion alone.
- You must have the force of moral conscience behind it.
- You must have every man—from the manufacturer who makes airplanes and engines to the airline head who operates them—from the mechanic who tunes up the engines to the pilot who flies the plane—from the CAA official who checks on flying procedures to Mr. John Q. Public who merely rides in the airplane . . . all these are part of the team.
- You may have the best engineering, the best designing, the finest maintenance and the most skillful pilots, but unless you have human team-work, the challenge of Flight Safety will not be adequately met.

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